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ABSTRACT

To explore the effectiveness of color coding of visual materials in improving student retention, two sets of black/white and color presentations and evaluative measures were developed and tested on 152 students. Instruction was identical in narrative and visual content, with the only variable the use of color in simple line drawings complementing the audiotaped instruction. Evaluative measures administered immediately and two weeks after presentation depended on recall of information color-coded on the slide presentation. Results indicated that randomly selected students performed best immediately when given the black/white cueing, with no significant difference in the two-week delayed test analysis. (SK)

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An Exploratory Study .n Maximizing Retention by Utilizing Black/White and Color Coding in Visualized Instruction

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An Exploratory Study in Maximizing Retention by
Utilizing Black/White and Color Coding in Visualized Instruction

Background

Teachers currently are confronted with the problem of selecting and organizing effective visualized materials to complement regular classroom instruction. Inherent in this problem is a need for critical assessment of the available visualized materials. Twyford (1969:371) has verbalized the problem in the following manner:

> In view of the widespread use of currently available materials it would be educationally desirable to have materials tested and improved as much as possible. To do this requires a complete knowledge of what elements contribute to effective instructional materials.

Miel (1967) has found that all students do not go through the same learning sequences in arriving at a similar point in learning; consequently, mere coverage of a topic is no guarantee that any particular achievement level will be obtained. There seems to exist a set of undefined rules for interpreting even the simplest information (Travers, 1970). Coding may be this set of rules the student needs to acquire in order to achieve optimal acquisition of visualized instruction and subsequent recall in the evaluation of visualized instruction. In summary of the basic problem, Dwyer (1972:7, 8) offers the following statement after an extensive survey of the literature on color, used as a coding cue in visuals:

> Although color is an important variable in the design and cost of instructional materials, the research concerning its effectiveness in increasing student learning is at best inconclusive . . . . There is very little experimental evidence available as to how the addition of color to various types of visual illustrations will affect student achievement . . . . It appears that guidelines for the use of color should be established as quickly as possible.

Statement of the Problem

The purpose of this exploratory study was: (a) to measure the relative effectiveness of two types of cueing (color and black/white) found in simple line drawings on immediate and delayed retention tests, (b) to determine whether the two different types of cueing are equally effective in facilitating student achievement on different educational tasks, (c) to determine whether student achievement is effected by altering a conditioned visual cueing pattern for different educational tasks, (d) to determine the relative retentional value of two types of cueing.

Instructional Materials and Procedure

Throughout the investigation considerable effort was taken to insure that the visualized materials were identical in terms of content for all treatments, the only difference being the technique of cueing: color or black/white. The preparation and design of materials entailed two complete sets of audio and visual materials for presentation and evaluation. Each will be discussed separately.

Preparation of the Presentation Materials.

The instructional presentation was developed by the investigator and validated for content by personnel from The University Division of Instructional Services. The instructional script was on the Panasonic, Model 8100, Video Tape Recording System. Recording of the script on audiotape cassette was done by a professional narrator. In addition to the oral dialogue heard by the students via audiotape cassette, a topical outline of the content material was prepared and projected simultaneously with its appropriate visual illustration. The purpose of the projected visual illustration and topical outline was to allow for individual learning preferences during the instructional presentation. Both visual illustration and topical outline were identically cued either color or black/white, depending upon which treatment the illustrations were intended for.

A synchronizing pulse was placed on each audiotaped cassette permitting the narration and corresponding visual illustration and topical outline to be simultaneously heard and viewed via tape recorder and carousel slide projectors. The visual illustrations consisted of simple line drawings depicting various components to the video recorder system. The drawings were prepared by a professional artist.

A set of various colored diazo overlays and corresponding set of black diazo overlays, illustrating the specific location and spelling of each instructional part, were also prepared. Care was taken to assure the correct spelling of the words, consistency in size and lettering style, and location of labeling words for each set of visual materials. Emphasis on location of each part was indicated by means of a straight line between the printed word and the part being illustrated. Isolation of each part from the remainder of the visual was indicated by means of shading out, with colored or blackened diazo, the location of each instructional part. Slides were then taken of each instructional part using the same base line drawing, altering the cueing diazo overlays: color or black/white.

The completed presentation material consisted of two sets of instructional materials consisting of an audiotape cassette and 88 pairs of 2 x 2 slides (visual illustration and topical outline), varying only in the cueing variable.

Preparation of the Evaluation Materials.

The evaluation materials were written by the investigator and validated by personnel from The University Division of Instructional Services. Production of the audiotaped cassette, visual illustrations, and slides used in evaluation were produced in exactly the same method as the instructional presentation materials.

The completed evaluation material consisted of two sets of materials consisting of an audiotaped cassette with narrative test directions and 30 pairs of 2 x 2 slides, varying only in the technique of cueing. The evaluation slides consisted of the five dependent variables, the criterion measures.

Criterion Measures

The criterion measures consisted of tasks measuring low cognitive skills. The four criterion measures: association task, terminology task, drawing task and knowledge task were summed to yield a fifth dependent variable, a total criterial task score. The total criterial task demonstrated the total understanding of the concepts presented (Kuder-Richardson Formula 20 Reliability = .89).

The set of association task slides consisted of 15 visual illustrations. The task slides were the identical slides which were used in the instructional presentation; the only difference was that the labeling word identifying the instructional part was removed. The student was asked to write the correct word for each visual next to the corresponding number on the answer sheet. The task requires the student to associate the visual with a specific fact of knowledge, the proper label.

The set of terminology task slides consisted of 15 visual illustrations depicting incomplete sentences. The slides were cued in the same manner as the topical outline slides in the instructional presentation. The task requires the student to demonstrate knowledge with a large number of words in their common range of meanings.

The drawing test slides consisted of two slides with 16 labels of parts. The student was asked to draw a simple line drawing of the video tape recorder console, locating and labeling the parts with the proper term. The student was also asked to trace the route of a threaded video tape. The task requires the recall of specific and isolated bits of information.

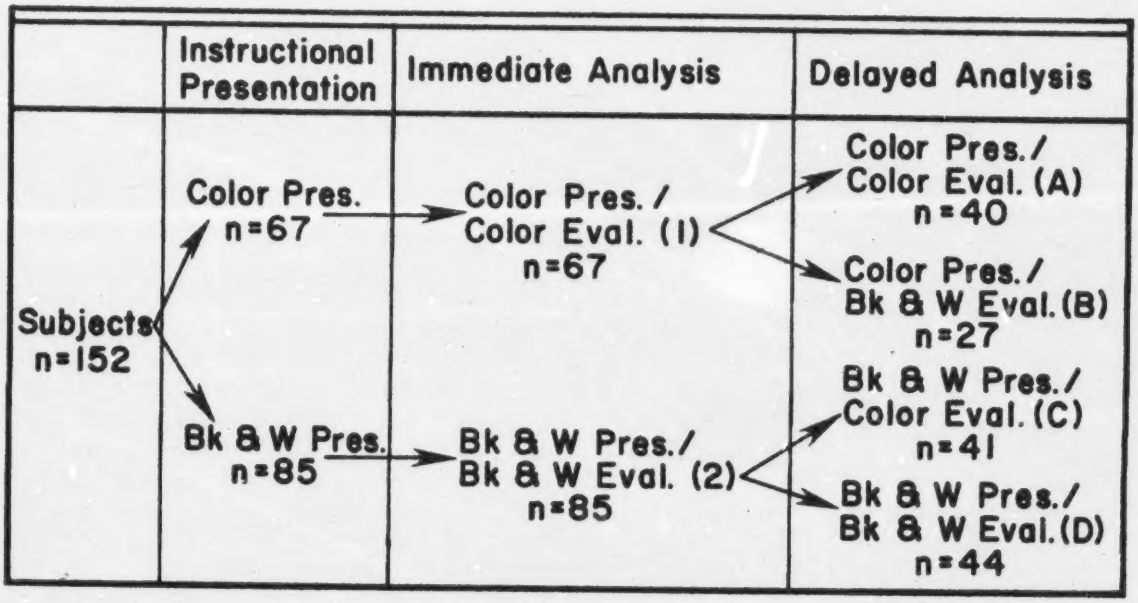
The set of knowledge task slides consisted of 10 multiple choice questions and 5 true or false questions. The slides were cued in the same manner as the topical outline slides in the instructional presentation. The task requires the student to recall specifics and universals regarding the processes involved in the use of a video tape recording system.

Treatments

The sample population for this investigation consisted of 152 students who were enrolled in Instructional Media 411 at The Pennsylvania State University. Students were randomly assigned to treatment conditions for both the immediate analysis and the delayed analysis.

The random assignment of students to treatments may be best represented in Table 1. The investigation contained two treatments (1 & 2) at the immediate analysis and four treatments (A, B, C & D) at the delayed analysis.

Table 1. Summary of Subjects by Treatments and Analysis


Instructional Presentation
Immediate Analysis
Delayed Analysis
Subjects n=152
Color Pres. n=67
Bk & W Pres. n=85
Color Pres. / Color Eval. (1) n=67
Bk & W Pres./ Bk & W Eval. (2) n=85
Color Pres./ Color Eval. (A) n=40
Color Pres./ Bk & W Eval. (B) n=27
Bk & W Pres./ Color Eval. (C) n=41
Bk & W Pres./ Bk & W Eval. (D) n=44

Treatment (A). Students in treatment (A) received audiotaped instruction complemented by color cued visuals and a color cued immediate retention test. For immediate analysis, treatment (A) was a subset of treatment (1). Students in treatment (A) received a color cued delayed retention test two weeks after the instructional presentation.

Treatment (B). Students in treatment (B) received audiotaped instruction complemented by color cued visuals and a color cued immediate retention test. For immediate analysis, treatment (B) was a subset of treatment (1). Students in treatment (B) received a black/white cued delayed retention test two weeks after the instructional presentation.

Treatment (C). Students in treatment (C) received audiotaped instruction complemented by black/white cued visuals and a black/white cued immediate retention test. For immediate analysis, treatment (C) was a subset of treatment (2). Students in treatment (C) received a color cued delayed retention test two weeks after the instructional presentation.

Treatment (D). Students in treatment (D) received audiotaped instruction complemented by black/white cued visuals and a black/white cued immediate retention test. For immediate analysis, treatment (D) was a subset of treatment (2). Students in treatment (D) received a black/white cued delayed retention test two weeks after the instructional presentation.

Design

For all treatment groups, the content of the instructional presentation and immediate and delayed retention tests was identical. The only independent variable in the instructional presentation and the retention tests was the technique of cueing used in the visual illustrations. The dependent variables consisted of five criterion measures evaluating student achievement on different educational tasks.

All statistical tests were conducted at .05 level for alpha. Upon completion of the instructional presentation subjects in treatments (1) and (2) were administered an immediate retention test, also containing the independent variable of cueing. Analysis of the immediate retention test was conducted via Behrens-Fisher t-tests for the five dependent criterion measures.

Two weeks after the immediate retention test, subjects were randomly assigned to four new treatments (A), (B), (C), and (D). A delayed retention test identical in content to the immediate retention test was administered to subjects in treatments (A) and (D). Treatments (B) and (C) received a delayed retention test opposite in cueing technique then received on the immediate retention test. Analysis of the delayed retention test was conducted via one-way analysis of variance on each of the five criterion measures. Multiple comparisons between treatment means were analyzed via Tukey's WSD-Procedure.

A retention analysis, which is computed by subtracting the delayed test scores from the immediate test scores, was conducted in the same manner as the delayed analysis.

Findings

Immediate Analysis. Multiple Behrens-Fisher t-tests on the five criterion measures indicated that significant differences existed on the terminology task ($t = 1.983$, $df = 115$, $p. < .05$), knowledge task ($t = -4.238$, $df = 135$, $p. < .01$), and the total criterial task ($t = -2.396$, $df = 117$, $p. < .05$). Thus in three out of five immediate criterion measures, the black/white cueing technique was more effective for facilitating student achievement (see Figure 1; Tables 2 and 3).

Delayed Analysis. An analysis of variance conducted on the scores achieved on the evaluative measures indicated that no significant differences existed on the five criterion measures (see Figure 2, Tables 4 and 5). Bartlett's Test for homogeniety of variances was conducted on all analysis of variance tests; all tests for homogeniety yielded insignificant chi-square distributions at the .05 level of alpha.

Figure 1. Plot of the Treatment Means for the Different Educational Tasks for the Immediate Retention Analysis

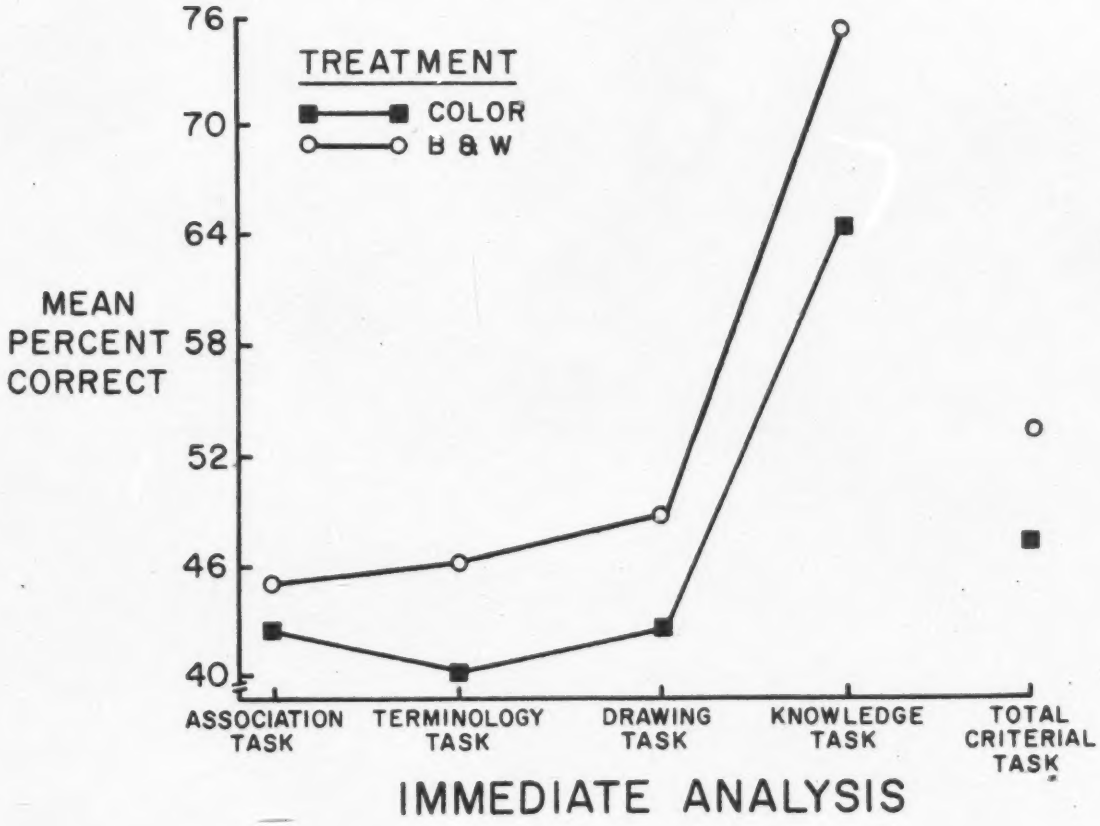


Table 2. Treatment Summary Table for the Immediate Retention Analysis

CRITERION MEASURES	Instructional Treatments: (1) Color Presentation/ Color Evaluation n= 67 MEAN	S.D.	(2) Bk. & W. Presentation/ Bk. & W. Evaluation 85 MEAN	S.D.
Association Task	42.59	25.30	44.48	18.78
Terminology Task	39.80	22.26	46.20	15.97
Drawing Task	42.05	22.68	48.79	18.91
Knowledge Task	63.98	15.83	74.43	14.10
Total Criterial Task	46.94	18.31	53.32	13.33

Table 3. Summary of the Statistical Analyses on the Different Educational Tasks for the Immediate Retention Analysis

CRITERION MEASURES	df	t-Value	Results of Treatment Mean Comparisons
Association Task	118	-0.510	Color (1)=Black and White (2)
Terminology Task	115	-1.983*	Black and White (2)>Color (1)
Drawing Task	128	-1.955	Color (1)=Black and White (2)
Knowledge Task	133	-4.238**	Black and White (2)>Color (1)
Total Criterial Task	117	-2.396*	Black and White (2)>Color (1)

*$p < .05$ **$p < .01$

Figure 2. Plot of the Treatment Means for the Different Educational Tasks for the Delayed Retention Analysis

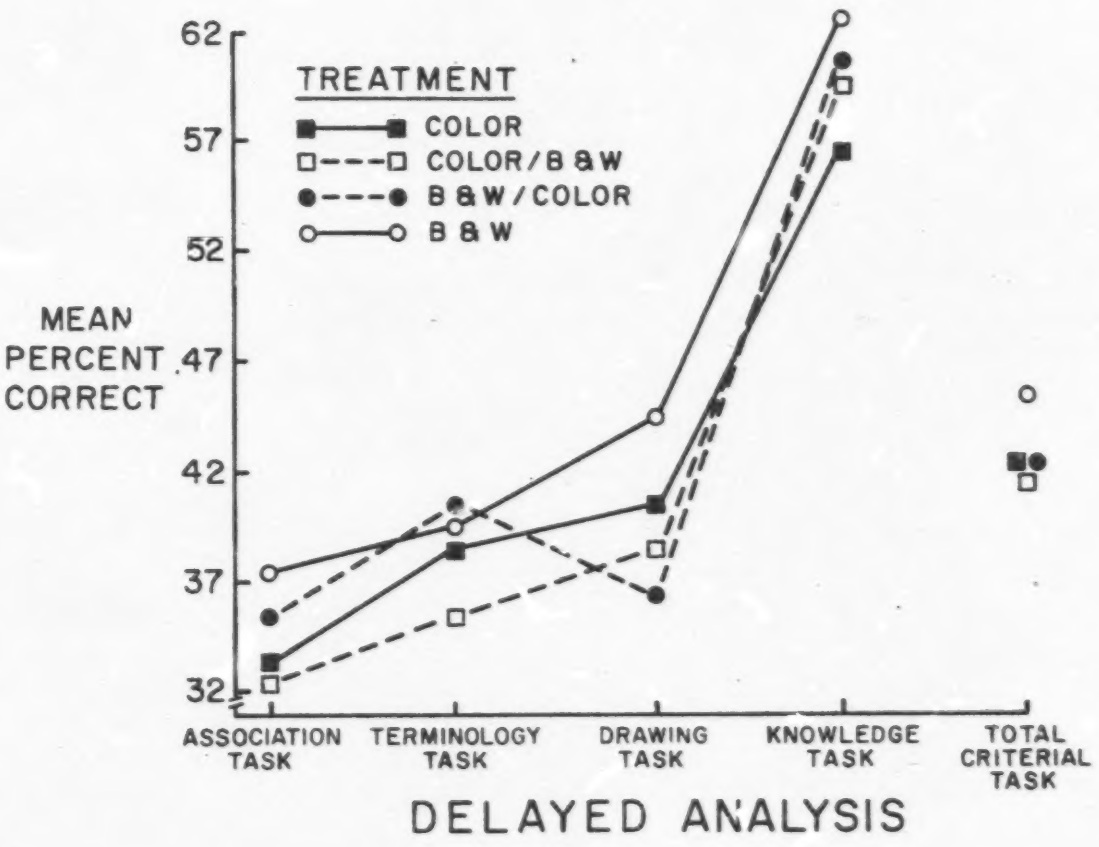


Table 4. Treatment Summary Table for the Delayed Retention Analysis

CRITERION MEASURES	Instructional Treatments (A) Color Pres./ Color Eval. n= 40 MEAN	S.D.	(B) Color Pres./ Bk. & W. Eval. 27 MEAN	S.D.	(C) Bk. & W. Pres./ Color Eval. 41 MEAN	S.D.	(D) Bk. & W. Pres./ Bk. & W. Eval. 44 MEAN	S.D.
Association Task	33.16	18.46	32.10	15.42	35.13	13.91	37.27	16.98
Terminology Task	38.33	20.57	35.06	20.22	39.51	15.66	39.09	17.40
Drawing Task	40.44	18.23	37.91	15.17	36.01	16.86	43.98	17.05
Knowledge Task	56.33	15.69	59.01	16.40	59.84	14.41	61.51	14.93
Total Criterial Task	42.02	14.53	40.92	13.45	42.41	12.26	45.42	13.36

Table 5. Summary of the Statistical Analyses on the Different Educational Tasks for the Delayed Retention Analysis

CRITERION MEASURES	F-Ratio (df=3/148)	Results of Treatment Mean Comparisons
Association Task	0.702	A = B = C = D
Terminology Task	0.778	A = B = C = D
Drawing Task	1.696	A = B = C = D
Knowledge Task	0.833	A = B = C = D
Total Criterial Task	0.790	A = B = C = D

*p < .05 **p < .01

Retention Analysis. An analysis of variance conducted on the informational loss scores, derived by subtracting the delayed retention test scores from the immediate retention test scores, indicated that significant differences existed on four of five criterion measures. Significant differences were achieved on the terminology task ($F = 3.825$, $df = 3/148$, $p. < .05$), drawing task ($F = 3.200$, $df = 3/148$, $p. < .05$), knowledge task ($F = 4.443$, $df = 3/148$, $p. < .01$), and the total criterial task ($F = 2.841$, $df = 3/148$, $p. < .05$). Analysis of the differences between pairs of treatment means, via Tukey's WSD-Procedure, indicated that on the terminology task the line drawing presentation and evaluation with color cueing was found to be less receptive to informational loss than the line drawing presentation and evaluation with black/white cueing (Treatment (A) < Treatment (D), $t = 3.20$, $df = 148$, $p. < .01$). Also the color cued line drawing presentation and evaluation was found to reduce informational loss more than the black/white cued presentation with color cued evaluation for the drawing task (Treatment (A) < Treatment (C), $t = 3.05$, $df = 148$, $p. < .05$). On the knowledge task, the color cued presentation with black/white evaluation was significantly less receiptive to informational loss than the black/white cued presentation with color cued evaluation (Treatment (B) < Treatment (C), $t = 3.45$, $df = 148$, $p. < .01$). Lastly, although the F-ratio for the total criterial task was significant, investigation of the differences between means revealed no significant multiple comparisons. It must be assumed that the variation causing the significant F-ratio is attributable to something other than the main variable - cueing. Visual examination of the data reveals a possible presentation X evaluation interaction which needs examination in another study (see Figure 3; Table 6).

Summary and Conclusions

The purpose of this exploratory study was: (a) to measure the relative effectiveness of two types of cueing (color and black/white) found in simple line

Figure 3. Plot of the Treatment Means for the Different Educational Tasks for the Retentional Analysis

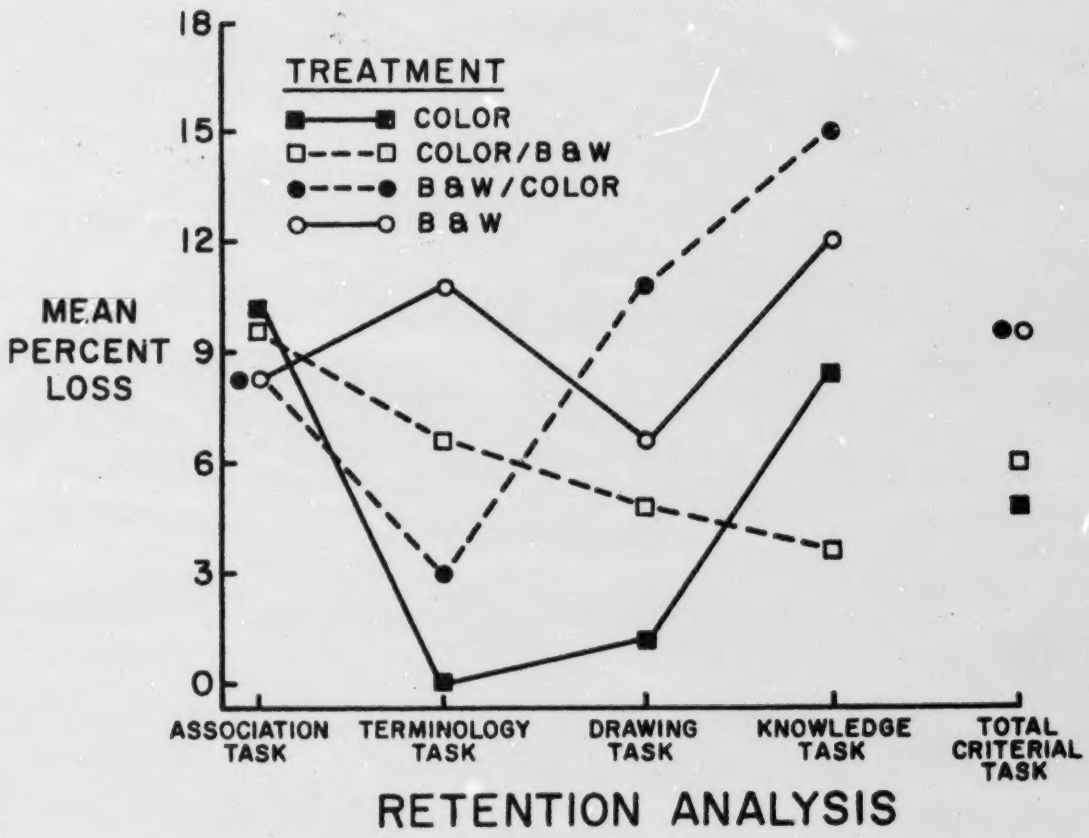


Table 6. Summary of the Statistical Analyses of the Different Educational Tasks for the Retentional Analysis

I. Association Task, F-Ratio (df=3/148)=0.157

Treatment	n	S.D.	MEAN	WSD-Treatment Comparisons (B) (9.39)	(C) (8.13)	(D) (8.33)
Color Pres./Color Eval. (A)	40	16.33	10.17	0.21	0.60	0.55
Color Pres./Bk. & W. Eval. (B)	27	15.60	9.39		0.33	0.28
Bk. & W. Pres./Color Eval. (C)	41	15.39	8.13			0.06
Bk. & W. Pres./Bk. & W. Eval. (D)	44	13.73	8.33			

II. Terminology Task, F-Ratio (df=3/148)=3.825*

Treatment	n	S.D.	MEAN	WSD-Treatment Comparisons (B) (6.67)	(C) (2.93)	(D) (10.61)
A	40	13.71	0.16	1.75	0.83	3.20**
B	27	13.07	6.67		1.00	1.08
C	41	15.49	2.93			2.36
D	44	16.55	10.61			

III. Drawing Task, F-Ratio (df=3/148)=3.200*

Treatment	n	S.D.	MEAN	WSD-Treatment Comparisons (B) (4.57)	(C) (11.05)	(D) (6.41)
A	40	14.25	1.32	0.91	3.05*	1.62
B	27	14.35	4.57		1.82	0.53
C	41	14.95	11.05			1.49
D	44	13.94	6.41			

IV. Knowledge Task, F-Ratio (df=3/148)=4.443**

Treatment	n	S.D.	MEAN	WSD-Treatment Comparisons (B) (3.45)	(C) (15.28)	(D) (12.27)
A	40	13.09	8.66	1.51	2.15	1.19
B	27	15.28	3.45		3.45**	2.61
C	41	12.94	15.28			1.00
D	44	14.38	12.27			

V. Total Criterial Task, F-Ratio (df=3/148)=2.841*

Treatment	n	S.D.	MEAN	WSD-Treatment Comparisons (B) (5.97)	(C) (9.40)	(D) (9.31)
A	40	9.24	4.96	0.48	2.36	2.35
B	27	8.72	5.97		1.63	1.61
C	41	7.96	9.40			0.05
D	44	8.07	9.31			

*p < .05 **p < .01

drawings on immediate and delayed retention tests, (b) to determine whether the two different types of cueing are equally effective in facilitating student achievement on different educational tasks, (c) to detemine whether student achievement is effected by altering a conditioned visual cueing pattern for different educational tasks, (d) to determine the relative retentional value of two types of cueing.

Two sets of presentation and evaluation audio-slide materials were developed to be the same in narrative and visual content, yet varying on the independent visual variable of cueing technique: color or black/white. Inherent to the presentation materials were simple line drawings developed to complement the audiotaped instruction; while five evaluative measures were developed to assess student achievement of different low cognitive skills presented in the instruction. Key to the procedure was the utilization of the same visual cueing technique in the presentation and evaluation materials.

One hundred and fifty-two college students were randomly assigned to treatment conditions. Each student interacted with the instructional presentation and completed an immediate and two week delayed test on the five evaluative measures. The results of this study suggest a number of conclusions to be taken into consideration in the preparation of simple line drawings to complement verbal instruction.

(1) Results indicated that the amount of student achievement attributable to differing cueing technique (color & black/white) varies significantly in immediate testing for different educational tasks. Analysis generally favored the black/white treatment condition.

(2) There appears to be no significant achievement difference attributable to cueing technique at a two week delayed test analysis for different educational tasks.

(3) Mean treatment scores reflected a trend that by altering a conditioned cueing technique in delayed evaluative testing, the loss of student achievement is appreciable for different educational tasks (see Figure 4).

(4) A significant mean difference was found among treatment conditions in analysis of the retentional value of cueing technique. Significance was interpreted as having originated due to different post instruction achievement, as reflected by immediate test analysis, rather than attributable directly to a particular cueing technique.

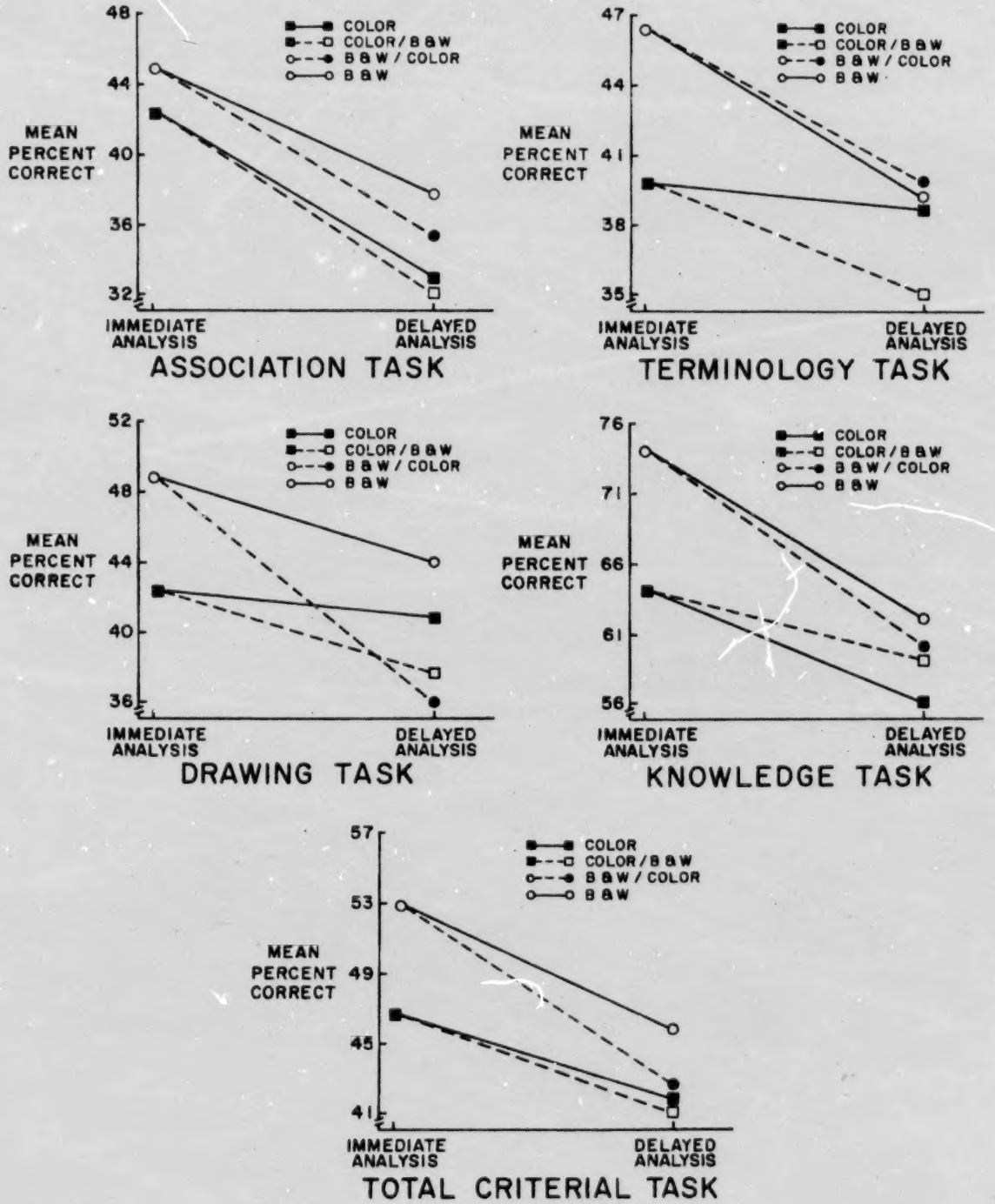
Discussion

The data collected in this study appears to support the contention that the mere addition of color in visualized instruction does not mean an efficient increase in student achievement. There appears to be other related factors.

The effectiveness of the black/white treatment in immediate analysis can be attributable to the pacing and the narration during presentation. The external pace of the audio-slide presentation and evaluation did not permit review, reinforcement, or recall of the desired paired response. Thus there appears to have been insufficient time for a significant conditioned association between color code and concept to develop. Furthermore the combination of pace, color coding, and audio narration might have surpassed the known human filtering capacity. Thus, the addition of color might have become an irrelevant cue because of pace and narrative dominance.

The data indicated in both the immediate analysis and the delayed analysis that the effectiveness of visualization to facilitate student achievement decreased as the level of cognitive task increased. This might be attributable to instrumentation or design rather than attributable to the factor of visualization. It is recommended that the data needs to be substantiated before a concrete intrepretation can be made. The data also indicated a definite trend of information

Figure 4. Plots of the Treatment Means for Immediate and Delayed Testing for Different Educational Tasks



loss for the altered cueing treatments (B and C); this suggests that a consistency between presentation and evaluation modes should be considered once a visual code has been conditioned. The resulting no significant differences in the delayed analysis, and the resulting mixed significant differences in the retention analysis should be interpreted with extreme caution. The results of the two analyses appear more attributable to a regression about the mean and differing levels of immediate retention rather than attributable to a specific coding effect.

This exploratory study has revealed that different coding techniques do elicit varying levels of student achievement for different educational tasks. Further studies will investigate the effect upon information loss and retention when subjects are conditioned to a specific competency level for a given coding technique during presentation of the instructional materials. What also would be the instructional effect of coding if the pace were altered from external to internal. Lastly there appears to be a need to separate coding techniques by a multifactor design to investigate the relationship and interaction of presentation to evaluation (modality consistency), pace (external vs. internal), time (immediate retention vs. delayed retention), educational task (objectives), and individual learner characteristics.

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